Expansion of the Universe and the equivalence of time and space.

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The reason for the expansion of the Universe is the equivalence of space and time, which strictly follows from A. Einstein's STR. For the derivation of the equivalence of space and time, see the link [1].

The equality of space and time logically follows from STR and the very concept of the space-time continuum. Here's a quote [2]:

"...In cosmology and relativistic physics in general, the concept of space-time unites space and time into one abstract Universe...

According to the theory of relativity, the Universe has three spatial dimensions and one temporal dimension, and all four dimensions are organically linked into a single whole, being almost equal in rights and within certain limits... capable of passing into each other when the observer changes the frame of reference.

Within the framework of the general theory of relativity, space-time also has a single dynamic nature, and its interaction with all other physical objects (bodies, fields) is gravity...

However, in special relativity, the distance between two points is no longer preserved when measured by two different observers due to Lorentz contraction if one of the observers is moving. The situation becomes even more complicated if the two points are separated by both distance and time.

For example, if one observer sees two events occurring at the same place but at different times, an observer moving relative to the first will see two events occurring at different locations. Thus, to measure the effective "distance" between two events, you will have to use a different way of measuring.

In four-dimensional space-time, the analog of distance is "interval". Although time is included in the fourth dimension, it is treated differently from the spatial dimensions and therefore the Minkowski space differs significantly from the four-dimensional Euclidean space.

The main reason for the merging of space and time into spacetime is that space and time are not invariant, that is, under appropriate conditions, different observers will disagree about the span of time (due to time dilation) or distance (due to Lorentz contraction) between two events. But special relativity provides a new invariant called the space-time interval, which unifies distances in space and time. All observers who measure time and distance will receive the same spacetime interval between any two events...".

So space and time are equivalent. That is, spatial dimensions can pass into temporal ones, and vice versa.

But, time flows from the past to the future (through the present)! Therefore, we perceive time as a certain arrow of time directed from the past to the future.

The existence of an arrow of time means that a moment in time in the present is unique, and therefore the next moment will be a different moment in time. People perceive this as the fact that there is only the present in which we live.

But!!! If time always changes and flows into the future, and at the same time there is an equivalence of time and space (they can pass into each other), then the uniqueness of space also appears logically.

Consequently, space, like time, must change in a certain way, that is, undergo a kind of "flow". We perceive and fix this "flow of space" as an "expansion" of the Universe.

It follows from the above that if there is an arrow of time, then the "flow" of space (or "expansion") will always exist.

Our universe is a space-time continuum. The universe is everything that can exist. Consequently, there can be no real "expansion" of the Universe - there is simply nowhere.

The Universe also cannot evolve, since there is no external observer, according to whose clock the Universe should evolve (there is only the Universe!). In cosmology, there is no arrow of time, but according to Einstein's special relativity, there is an equivalence of time and space, which leads to the observed "expansion of the Universe" (because we are watching the arrow of time).

This means that the "expansion of the Universe" should be perceived as a kind of "internal movement" of the Universe similar to the spin of microparticles. In fact, we must recognize that the "expansion of the universe" is a purely quantum property of the universe, from which follows the uniqueness of each moment of time and the uniqueness of each spatial position in the Universe.

Spin, as is known, is a quantum characteristic of particles, which has no classical analogy [3]:

"...Unlike the orbital angular momentum, which is created by the motion of a particle in space, spin is not related to motion in space. Spin is an internal, purely quantum characteristic that cannot be explained within the framework of relativistic mechanics...

In particular, it would be completely meaningless to represent the intrinsic moment of an elementary particle as a result of its rotation "around its own axis"...".

From the equivalence of space and time, the Heisenberg uncertainty principle also logically follows - with a constant "flow" of time and space coordinates, it is simply impossible to establish their exact fixed value for

a particle - it simply does not exist. And there is a certain “wave of changes” in these coordinates, which imposes certain restrictions on accurately measuring the coordinate and velocity of a particle.

This “wave of changes” in the coordinate and velocity of the particle manifests itself as a corpuscular-wave dualism: sometimes a point particle is fixed, sometimes a certain “matter wave” (de Broglie wave).

A good illustration of the “flow” of spatial and temporal coordinates is a video of the movement of the Earth, the Sun and planets in the galaxy (the galaxy moves in the Universe), since the uniqueness of each moment of time and the uniqueness of the corresponding spatial coordinates of the Earth's position can be observed with your own eyes:

In this place of the Universe, our Earth will never be again... The location of the Earth in the Universe, like every moment of time, is truly unique.

It should also be noted that according to Einstein's GR, mass and space-time are inseparable: if matter exists, then space-time exists, and vice versa.

Space is a mathematical abstraction, like Newtonian space. In reality, only our Universe exists, that is, the space-time continuum, which is the Universe.

Consequently, the space-time continuum in which we live (and also feel it as a three-dimensional space and time) arises as a result of the interaction between all the elementary particles of our Universe. Moreover, each elementary particle fills the entire Universe (even if the Universe is infinite). The matter of the Universe can be represented as the final result of the interaction of elementary particles with each other.

As a result, we have an interfering Universe in which all elementary particles interact with each other in various ways (that is, they interfere).

Thus, one quantum of space (or time) is one elementary particle that really exists and fills the entire Universe. In this case, the particle participates in the creation of the space-time continuum of the Universe.

As a consequence, we have continuous space and time with virtually infinite resolution, since both space and time are simply a certain mathematical function of the matter of the Universe.

1. Bezverkhniy V. D. Equivalence of space and time. ResearchGate (May 2021). http://dx.doi.org/10.13140/RG.2.2.10932.78727

2. Spacetime. Wikipedia (ru). https://en.wikipedia.org/wiki/Spacetime

3. Landau L. D., Lifshits E. M. Theoretical Physics. Vol. III (1989). Quantum mechanics. Moscow: Nauka. Chapter VIII, § 54 Spin, p. 242-243.